

**Exhibit A to**  
**Second Response to Office Action**

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**CS152**  
**Computer Architecture and Engineering**  
**Lecture 5: Cost and Design**

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**lecture slides: <http://www-inst.eecs.berkeley.edu/~cs152/>**

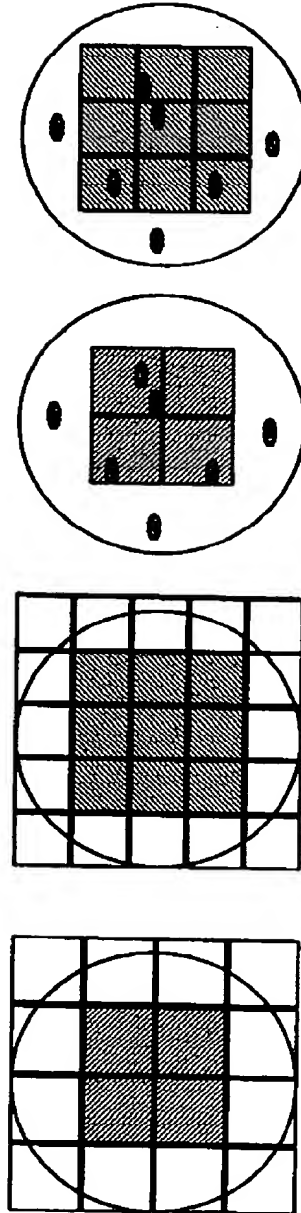
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# Integrated Circuit Costs

$$\text{Die cost} = \frac{\text{Wafer cost}}{\text{Dies per Wafer} * \text{Die yield}}$$

$$\text{Dies per wafer} \sim \frac{\text{eff Wafer Area}}{\text{Die Area}}$$



$$\text{Die Yield} = \frac{\text{Wafer yield}}{\{ 1 + \frac{\text{Defects\_per\_unit\_area} * \text{Die\_Area}}{?} \}}$$

*Die Cost is goes roughly with the cube of the area.*

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## Die Yield

wafer diameter	Raw Dices Per Wafer					
	die area (mm <sup>2</sup> )					
	100	144	196	256	324	400
6"/15cm	139	90	62	44	32	23
8"/20cm	265	177	124	90	68	52
10"/25cm	431	290	206	153	116	90

die yield      23%    19%    16%    12%    11%    10%

typical CMOS process: ? =2, wafer yield=90%, defect density=2/cm<sup>2</sup>, 4 test sites/wafer

### Good Dices Per Wafer (Before Testing!)

6"/15cm	31	16	9	5	3	2
8"/20cm	59	32	19	11	7	5
10"/25cm	96	53	32	20	13	9

typical cost of an 8", 4 metal layers, 0.5um CMOS wafer: ~\$2000

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## Real World Examples

Chip	Metal layers	Line width	Wafer cost	Defect /cm <sup>2</sup>	Area mm <sup>2</sup>	Dies/ wafer	Yield	Die Cost
386DX	2	0.90	\$900	1.0	43	360	71%	\$4
486DX2	3	0.80	\$1200	1.0	81	181	54%	\$12
PowerPC 601	4	0.80	\$1700	1.3	121	115	28%	\$53
HP PA 7100	3	0.80	\$1300	1.0	196	66	27%	\$73
DEC Alpha	3	0.70	\$1500	1.2	234	53	19%	\$149
SuperSPARC	3	0.70	\$1700	1.6	256	48	13%	\$272
Pentium	3	0.80	\$1500	1.5	296	40	9%	\$417

From "Estimating IC Manufacturing Costs," by Linley Gwennap, *Microprocessor Report*, August 2, 1993, p. 15

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## Other Costs

IC cost = Die cost + Testing cost + Packaging cost

Final test yield

**Packaging Cost: depends on pins, heat dissipation**

Chip	Die cost	Pins	Package type	Package cost	Test & Assembly	Total
386DX	\$4	132	QFP	\$1	\$4	\$9
486DX2	\$12	168	PGA	\$11	\$12	\$35
PowerPC 601	\$53	304	QFP	\$3	\$21	\$77
HP PA 7100	\$73	504	PGA	\$35	\$16	\$124
DEC Alpha	\$149	431	PGA	\$30	\$23	\$202
SuperSPARC	\$272	293	PGA	\$20	\$34	\$326
Pentium	\$417	273	PGA	\$19	\$37	\$473

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